FY98 Basic Research Program

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LONG-TERM GOAL

The Basic Research Program at ARL:UT emphasizes the Laboratory's commitment to 6.1 research, utilizing the expertise of faculty, research staff, and students in collaborative efforts. Publishing in archival journals and focusing new 6.1 research thrusts in arenas of future naval significance is encouraged, as are transitions to possible future funding under other ONR and DoD programs.

FY98 RESEARCH PROJECTS

Development of a CIT Constrained Electronic Density Model, Dr. Gary Bust: The FY98 research effort focused on deriving a fairly simple model of the electron continuity equation, deriving a data assimilation method for the tomographic data, and implementing the forward model of the electron density. The approach adopted here is to include the neutral winds, gravity, and density diffusion terms in the electron velocity. A simplified form of the production term is adopted and the relevant flux values are taken from published results. The neutral composition will be obtained from the empirical MSIS90 model, and the neutral winds from the HWM93 model. FY99 will address the implementation of the adjoint equation for "initializing" the electron density, the minimization procedure, and testing of the results.

Three Dimensional Electromagnetic Propagation Using High Performance Computing, Dr. Roy Jenevein: The parabolic equation is inherently range-dependent, but has the disadvantage of being a marching solution in range. Two approaches to a parallel solution of this equation have been explored, the Tappert-Hardin split-step approach and an approach developed by Ding Lee, et al., which solves a series of tri-diagonal matrices. The Ding Lee approach shows the most promise for parallel speed-up. Software for this approach has been developed for acoustic propagation and is being adapted to the EM propagation problem. The Message Passing Interface (MPI) protocol has been chosen for parallel processor communications. Current development is on the HP/Convex Exemplar 1200 with 16 processors. Development will be continued on the University of Texas Cray T3E with 64 processors.

Identification of Elemental Composition by Electron Activated Nuclear Gamma Ray Spectroscopy, Dr. Robert Rogers: The current work is focused on modeling the interaction processes between the high energy electrons (50 to 100MeV) and target material. The model is GEANT. Modifications are currently being added to the code to include the effects of nuclear structure. Current modeling efforts are focused on computing signal-to-noise ratios for the nuclear structure states for materials of different impedances. This effort will provide a basis for assessing the application of 50 to 100MeV electrons as a tool for determining elemental composition of materials, especially materials that are either shielded or covered.

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Nonlinear Methods for Early Crack Detection and Localization, Dr. Gary Wilson: Cracks in structures are typically detected only when the structure is close to failure. The objective of this study is to develop methods of early crack detection. We have shown that in theory cracks of any size can affect the vibrational response of a structure by introducing nonlinear components. These nonlinear components can be observed at a low level using higher order spectral analysis and, in particular, bispectral analysis. The following year will demonstrate experimentally this method of detection and determine the limits of its applicability.

The Inversion of Ocean Waveguide Parameters from Measured Acoustic Data, Dr. David Knobles: In February 1998 acoustic and environmental data were collected in a shallow water area of the Gulf of Mexico on a 52-element horizontal line array for the purpose of doing geoacoustic inversion studies. Broadband adiabatic normal mode calculations have been successful in fitting time series data generated by light bulb sources. From this preliminary analysis, an initial geoacoustic description has been obtained. Currently a cross-phone correlation matched-field approach is being united with a recently reported non-linear least squares algorithm in order to refine the initial geoacoustic description of the sea floor.

Neutralization of Explosives by Plasma Jet Impingement, Dr. Dennis Wilson: A pulse plasma jet is created by an electrothermal gun, a device that relies upon electrothermal vaporization of solid metal to produce metal vapor plasmas. Six tests have been conducted using an aluminum plasma on one gram specimens of PETN explosive. The effectiveness of the tests have been determined by post detonation experiments on the exposed specimens compared with detonations on unexposed specimens. To date the tests are inconclusive; however, preliminary results suggest that partial neutralization has been achieved.

The Near-Field Apertureless Raman Microscope: A Novel Tool for the Chemical Identification of Single Biomacromolecules, Dr. Robert Martinez: The focus of this project is the development of a new technique that will allow chemically specific imaging with spatial resolution of ~1nm. A Raman microscope system is expected to be completed by the end of November 1998. We have also acquired "benchmark" Raman spectra of cytoskeletal proteins and energy transfer macromolecules which will be used as a reference for our single molecule studies. We plan to use the new instrument to identify single biological molecules at the surface of a cell, and to explore single-molecule binding events.

Ultrasonic and Sonochemical Lysogenesis of Bacteria, Dr. Shelley Payne: Work during the past year has focused on (1) testing physical agents that enhance ultrasonic lysogenesis of bacteria and (2) testing flow-through devices for efficiency in killing bacteria by lysogenesis. We found that oxidative stress enhances killing; exposure to sublethal concentrations of peroxides or ferric ions during or immediately after insonification decreased bacterial survival. Testing of various flow-through devices has indicated that short transit times are associated with decreased killing, but excessive heating of the sample during longer transit was a complicating factor.

Development and Evaluation of a Multi-State Classifier, Dr. G. Douglas Meegan: This project is concerned with the detection and classification of land vehicles through an analysis of seismic and acoustic (air) signatures. Some of the features that can be extracted either manually or automatically include engine types, transmission types, and chassis arrangement. By constructing a database of over 400 international military and non-military vehicles, we have developed an automated chi-squared

statistical vehicle classifier that accepts detected features and the associated measurement uncertainty and produces a list of candidate vehicle matches.

HS High School Apprenticeship Program, Dr. Gary Wilson and Ms. Elaine Frazer: The purpose of the apprenticeship program is to provide outstanding recent high school graduates with hands-on experience in a research environment and encourage them to pursue careers in the science and engineering disciplines, particularly in those areas related to the needs of the Department of Defense. Students were selected on the basis of academic records, scholastic aptitude test results, and applications. Students were assigned to a research project under the supervision of a research staff member at ARL:UT. At the end of the apprenticeship in mid-August, students gave poster presentations to the laboratory.